

AMENDMENTS TO THE CLAIMS

1. (Original) A crosslinked polyrotaxane comprising at least two molecules of polyrotaxane, in which a linear molecule is included in cavities of cyclodextrin molecules in a skewed manner, wherein the linear molecule has at each end a capping group to prevent the dissociation of the cyclodextrin molecules, the at least two molecules of polyrotaxane are crosslinked with each other through physical bonding, and a part or all of hydroxyl groups (-OH) of cyclodextrin molecules are substituted with a non-ionic group(s).

2. (Withdrawn - previously presented) The crosslinked polyrotaxane according to claim 1, wherein the crosslinked polyrotaxane has a reversible ability to respond to external stimulus, which reversibly varies from an uncrosslinked state or crosslinked state to a crosslinked state or uncrosslinked state depending on the presence or absence of an external stimulus.

3. (Withdrawn) The crosslinked polyrotaxane according to claim 2, wherein the external stimulus is heat, and the crosslinked polyrotaxane transforms from the uncrosslinked state to a gel state as the crosslinked state in a first temperature range ranging from 5 to 90°C.

4. (Withdrawn - previously presented) The crosslinked polyrotaxane according to claim 3, which transforms from the gel state as the crosslinked state to the uncrosslinked state in a second temperature range, which is higher than the first temperature range, and which ranges from 10 to 100°C.

5. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -OR group, and R is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3-12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

6. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -O-R'-X group, and R' is a group resulting from removal of one hydrogen in a linear or branched alkyl group having 1–12 carbons, a group resulting from removal of one hydrogen in a linear or branched alkyl group having 2–12 carbons and at least one ether group, a group resulting from removal of one hydrogen in a cycloalkyl group having 3–12 carbons, a group resulting from removal of one hydrogen in a cycloalkyl ether group having 2–12 carbons or a group resulting from removal of one hydrogen in a cycloalkyl thioether group having 2–12 carbons, and X is OH, NH₂ or SH.

7. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -O-CO-NH-R₁ group, and R₁ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

8. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -O-CO-R₂ group, and R₂ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

9. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -O-Si-R₃ group, and R₃ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

10. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the non-ionic group is a -O-CO-O-R₄ group, and R₄ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

11. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein substitution of the hydroxyl group with the non-ionic group is 10 to 100% of the total hydroxyl groups of the total cyclodextrin molecules.

12. (Currently amended) The crosslinked polyrotaxane according to claim 1, wherein the cyclodextrin ~~molecule~~ is molecules are selected from the group consisting of α -cyclodextrin, β -cyclodextrin and γ -cyclodextrin.

13. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the linear molecule is selected from the group consisting of polyethylene glycol, polyisoprene, polyisobutylene, polybutadiene, polypropylene glycol, polytetrahydrofuran, polydimethylsiloxane, polyethylene and polypropylene.

14. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the capping group is selected from the group consisting of dinitrophenyl groups, cyclodextrins, adamantane groups, trityl groups, fluoresceins, pyrenes, substituted benzenes, polycyclic aromatics that may be substituted, and steroids.

15. (Currently amended) The crosslinked polyrotaxane according to claim 1, wherein the cyclodextrin ~~molecule~~ is molecules are α -cyclodextrin, and the linear molecule is polyethylene glycol.

16. (Previously presented) The crosslinked polyrotaxane according to claim 1, wherein the linear molecule has the cyclodextrin molecules included in a skewered manner at an amount of 0.001 to 0.6 of a maximum inclusion amount, which is defined as an amount at which the cyclodextrin molecule can be included at maximum when the linear molecule has the cyclodextrin molecules included in a skewered manner, and the amount at maximum is normalized to be 1.

17. (Original) A method for preparing a crosslinked polyrotaxane comprising the steps of:

1) mixing cyclodextrin molecules and a linear molecule, to prepare a pseudopolyrotaxane in which the linear molecule is included in cavities of the cyclodextrin molecules in a skewered manner;

2) capping each end of the pseudopolyrotaxane with a capping group to prevent the dissociation of the CD molecules, to prepare a polyrotaxane;

3) substituting a part of OH groups of the cyclodextrin molecules with a non-ionic group:

A) before the step 1) of mixing to prepare the pseudopolyrotaxane;

B) after the step 1) of mixing to prepare the pseudopolyrotaxane and before the step 2) of capping to prepare the polyrotaxane; and/or

C) after the step 2) of capping to prepare the polyrotaxane;

4) dissolving at least two molecules of the resultant polyrotaxane in a hydrophilic solvent; and

5) applying an external stimulus to the molecules of the polyrotaxane in the hydrophilic solvent to crosslink the at least two molecules of the polyrotaxane through physical bonding.

18. (Original) The method according to claim 17, wherein the external stimulus is heat, and the molecules of polyrotaxane transforms from an uncrosslinked state to a hydrogel state as a crosslinked state in a first temperature range ranging from 5 to 90°C.

19. (Previously presented) The method according to claim 18, wherein the molecules of polyrotaxane transforms from the hydrogel state as the crosslinked state to the uncrosslinked state in a second temperature range, which is higher than the first temperature range, and which ranges from 10 to 100°C.

20. (Previously presented) The method according to claim 17, wherein the polyrotaxane is dissolved so that a weight ratio of the polyrotaxane to the hydrophilic solvent is 0.1:99.9 to 70:30 in the step of dissolving.

21. (Previously presented) The method according to claim 17, wherein the step of substituting is set after the step 2) of capping to prepare the polyrotaxane.

22. (Withdrawn - previously presented) An external stimulus-responsive material having a reversible ability to respond to external stimulus, which reversibly varies from an uncrosslinked state or crosslinked state to a crosslinked state or uncrosslinked state depending on the presence or absence of an external stimulus, comprising the crosslinked polyrotaxane according to claim 1 and a solvent.

23. (Withdrawn) The material according to claim 22, wherein the external stimulus is heat, the solvent is water, and the material transforms from an uncrosslinked state to a crosslinked state, or crosslinked hydrogel state in a first temperature range ranging from 5 to 90°C.

24. (Withdrawn) The material according to claim 23, wherein the material transforms from the crosslinked state, or crosslinked hydrogel state to the uncrosslinked state in a second

temperature range, which is higher than the first temperature range, and which ranges from 10 to 100°C.

25. (Withdrawn - previously presented) The material according to claim 22, wherein a weight ratio of the crosslinked polyrotaxane to the solvent ranges from 0.1 : 99.9 to 70 : 30.

26 (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -OR group, and R is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

27. (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -O-R'-X group, and R' is a group resulting from removal of one hydrogen in a linear or branched alkyl group having 1–12 carbons, a group resulting from removal of one hydrogen in a linear or branched alkyl group having 2–12 carbons and at least one ether group, a group resulting from removal of one hydrogen in a cycloalkyl group having 3–12 carbons, a group resulting from removal of one hydrogen in a cycloalkyl ether group having 2–12 carbons or a group resulting from removal of one hydrogen in a cycloalkyl thioether group having 2–12 carbons, and X is OH, NH₂ or SH.

28. (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -O-CO-NH-R₁ group, and R₁ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

29. (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -O-CO-R₂ group, and R₂ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

30. (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -O-Si-R₃ group, and R₃ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

31. (Withdrawn - previously presented) The material according to claim 22, wherein the non-ionic group is a -O-CO-O-R₄ group, and R₄ is a linear or branched alkyl group having 1–12 carbons, a linear or branched alkyl group having 2–12 carbons and at least one ether group, a cycloalkyl group having 3–12 carbons, a cycloalkyl ether group having 2–12 carbons or a cycloalkyl thioether group having 2–12 carbons.

32. (Withdrawn - previously presented) The material according to claim 22, wherein substitution of the hydroxyl group with the non-ionic group is 10 to 100% of the total hydroxyl groups of the total cyclodextrin molecules.

33. (Withdrawn - previously presented) The material according to claim 22, wherein the cyclodextrin molecule is selected from the group consisting of α -cyclodextrin, β -cyclodextrin and γ -cyclodextrin.

34. (Withdrawn - previously presented) The material according to claim 22, wherein the linear molecule is selected from the group consisting of polyethylene glycol, polyisoprene,

polyisobutylene, polybutadiene, polypropylene glycol, polytetrahydrofuran, polydimethylsiloxane, polyethylene and polypropylene.

35. (Withdrawn - previously presented) The material according to claim 22, wherein the capping group is selected from the group consisting of dinitrophenyl groups, cyclodextrins, adamantane groups, trityl groups, fluoresceins, pyrenes, substituted benzenes, polycyclic aromatics that may be substituted, and steroids.

36. (Withdrawn - previously presented) The material according to claim 22, wherein the cyclodextrin molecule is α -cyclodextrin, and the linear molecule is polyethylene glycol.

37. (Withdrawn - previously presented) The material according to claim 22, wherein the linear molecule has the cyclodextrin molecules included in a skewered manner at an amount of 0.001 to 0.6 of a maximum inclusion amount, which is defined as an amount at which the cyclodextrin molecule can be included at maximum when the linear molecule has the cyclodextrin molecules included in a skewered manner, and the amount at maximum is normalized to be 1.